

11 August 1995

Europäisches  
PatentamtEuropean  
Patent OfficeOffice européen  
des brevets

REC'D 24 AUG 1995
WIPO PCT

Bescheinigung

Certificate

Attestation

08/732321

Die angehefteten Unterla-  
gen stimmen mit der  
ursprünglich eingereichten  
Fassung der auf dem näch-  
sten Blatt bezeichneten  
europäischen Patentanmel-  
dung überein.

The attached documents  
are exact copies of the  
European patent application  
described on the following  
page, as originally filed.

Les documents fixés à  
cette attestation sont  
conformes à la version  
initialement déposée de  
la demande de brevet  
européen spécifiée à la  
page suivante.

Patentanmeldung Nr. Patent application No. Demande de brevet n°

94303092.4

PRIORITY DOCUMENT
-------------------

Der Präsident des Europäischen Patentamts:  
Im Auftrag

For the President of the European Patent Office

Le Président de l'Office européen des brevets  
p.o.

N.A.S. Ketten

Den Haag, den  
The Hague,  
La Haye, le

31/07/95



**Europäisches  
Patentamt**



**European  
Patent Office**

**Office européen  
des brevets**

**Blatt 2 der Bescheinigung  
Sheet 2 of the certificate  
Page 2 de l'attestation**

Anmeldung Nr.:  
Application no.:  
Demande n°: **94303092.4**

Anmeldetag:  
Date of filing: **28/04/94**  
Date de dépôt:

Anmelder:  
Applicant(s):  
Demandeur(s):  
**BRITISH TELECOMMUNICATIONS public limited company**  
**London EC1A 7AJ**  
**UNITED KINGDOM**

Bezeichnung der Erfindung:  
Title of the invention:  
Titre de l'invention:  
**Service provision system for communications networks**

In Anspruch genommene Priorität(en) / Priority(ies) claimed / Priorité(s) revendiquée(s)

Staat:  
State:  
Pays:

Tag:  
Date:  
Date:

Aktenzeichen:  
File no.  
Numéro de dépôt:

Internationale Patentklassifikation:  
International Patent classification:  
Classification internationale des brevets:  
**H04Q7/24**

Bemerkungen:  
Remarks:  
Remarques:

SERVICE PROVISION SYSTEM FOR COMMUNICATIONS NETWORKS

The present invention relates to service provision in communications networks and finds particular application  
5 where a communications user is mobile.

Communication networks are growing increasingly complex as the information technology (IT) industry produces new and varied services to be offered to customers. The rapid provision of these services is expected to be a key  
10 feature in distinguishing different network operators. Competitive advantages can be gained by communications network operators through the services that they offer, and the efficiency with which they manage those services. The customers (users) do not want to be aware of network  
15 complexity, such as the relationship between fixed and mobile networks. All they want is simple access to any service, and this applies whether they are connected to a fixed network or using mobile facilities.

Embodiments of the present invention provide a service  
20 management system, which can be used in the provision of services to a mobile user by means of more than one network platform. In particular, embodiments of the present invention can be used to provide services by means of a combination of a fixed and a mobile communications network,  
25 in spite of the differing constraints such as the more limited bandwidth available in mobile networks.

It has been recognised, in making the present invention, that the use of "Cooperating Intelligent Software Agent" technology in a heterogeneous agent architecture can  
30 allow service management in a complex environment such as the above. The basis for this technology is described in general terms in the publication "Distributed Artificial Intelligence" by M Huhns, Volumes I and II, published by Pitman, Morgan and Kaufmann in 1987. Indeed, cooperating  
35 intelligent agents can be used to provide quality and flexibility of control sufficient to meet the demands of

leading-edge services, in spite of problems presented by multiple network platforms with conflicting constraints.

Embodiments of the present invention can be described as having a distributed architecture based on specialised intelligent software systems, that is agents, which cooperate to provide a range of services, some of which may be novel, across a network platform provided by integration of, for instance, a mobile and a fixed network platform. Software agents for use in embodiments of the present invention can be designed to manage systems where there is a large amount of distributed information available and a large number of users with specific service requirements. Generally system management becomes more complex where users move between fixed and mobile networks while requiring/receiving services. This raises the problem of unifying the provisioning of services across various network platforms (mobile and fixed) and the effective management of the limited radio spectrum in contrast with the less constrained bandwidth in the fixed (broadband) networks.

A major problem foreseen with communications systems of the future is system complexity which is expected to limit the ability to exploit and reliably control communication networks. Intelligent agents used in embodiments of the present invention can achieve simplicity and robustness by spreading a control system over a plurality of specialised agents.

One type of agent provides the customer with an interface to manage the customer's interactions with the network, another cooperates to manage the network resources (cell bandwidth or capacity along the fixed network links) and a third type of agent facilitates specific services by linking network and customers together. As a result of agents interaction, intelligent services with special features that satisfy the customer and make better use of network resource, can be provided.

The agents accomplish their tasks by exploiting only local knowledge and using limited communications to inform

each other of their actions and/or past knowledge. They negotiate with each other and by deciding the best option allocate tasks within the system. Their distributed nature makes them tolerant to both individual and multiple agent failure. This agent-based approach gives fast, robust and near-optimal solutions to resource allocation problems.

A service provision system according to an embodiment of the present invention will now be described, by way of example only, with reference to the accompanying Figures in which:

Figure 1 shows an environment in which the service provision system would be advantageous;

Figure 2 shows a schematic diagram of a heterogeneous agent architecture for use in the service provision system described below; and

Figure 3 shows schematically the relationship between network management software agents and a network over which they have control.

Referring to Figure 1, an environment in which the service provision system might be applied comprises a fixed communications network 1, which may for instance be a broadband network, in combination with radio transmitters 2 of a mobile network.

The fixed (broadband) network 1 is the main carrier of long distance traffic and is represented for the purposes of this example to consist solely of Digital Main Switching Units (DMSUs) 3 which are nearly fully interconnected. Houses 4, offices 5, other buildings etc are assumed to be connected in known manner to an appropriate node of the fixed network 1.

The radio part of the network is arranged into large (~10 km diameter) macro cells 6 and smaller (~500m diameter) micro cells 7. The former provide country wide coverage but a low bandwidth, the latter service local 'hotspots' with higher bandwidth available. Additional services are available through much higher bandwidth, small pico cells 8 - typically only a few meters across. These are assumed to be

located in offices 5 and at special location points such as garages, railways stations, motorway service stations, shopping centres etc. All radio cell transmitters 2 are connected in known manner to their local fixed network node.

5       The customer (user) may be mobile, travelling across cell boundaries 9 and requesting various services through his mobile handset, or may be at a fixed location having access to the integrated network through a terminal (ie video-telephone or computer terminal).

10       In this scenario, there will be at least one network provider involved, who provides and manages either one or both of the fixed and mobile networks concerned. There will also be at least one customer, who has access to one or both of the networks and may require services such as telephone  
15 calls or data provision, and at least one service provider. The service provider(s) may be independent of the network provider and merely provide services which are accessible by means of the network(s).

20

      Normally any requested service will involve an end-to-end connection across the integrated network platform to another mobile/fixed customer or to a bank of data located anywhere in the network. For instance, the data might  
25 comprise any kind of stored information (text file, image file, manual page) that the customer would like to access for information retrieval or storage.

#### Agents Architecture

30       Referring to Figure 2, the following describes a heterogeneous system architecture based on autonomous agents working cooperatively to solve various service management problems in the mobile and fixed integrated network (MFIN)  
10, shown in Figure 1.

35       The agents form a single layered system using the underlying fixed network 1 for inter-agent communication.

The agents involved in the architecture can be grouped into three generic categories:

- Interface agents comprising Customer Agents (CA) 20 and Gateway Agents (GA) 21.
- 5 - Service Provider Agents (SPAs) 22
- Network Management agents comprising Fixed Network Agents (FNA) 23 and Cell Agents (CLA) 24

A Customer Agent CA 20 mediates between the agent  
10 system 25 and the customer while a Gateway Agent GA 21 provides a link such as a port, or interface, between the agent system 25 <sup>and</sup> another intelligent or non-intelligent management system (not shown) owned by an independent telecom operator. Hence, GAs 21 facilitate the transfer of  
15 information or requests between the agent system 25 and the external world.

The Service Provision Agents 22 are each responsible for a specific service, managing information about the provider(s) of that service and negotiating with those  
20 providers <sup>who</sup> wish to sell their resources. In an example, a customer might require some specific data but that same data may be found at different locations.

In principle, each agent is allowed to communicate with any other agent in the community with the exception of  
25 SPAs 22 which have communication channels only with Customer Agents (CAs). This provides a security measure in that SPAs 22 for service providers who are independent of the relevant network provider(s) are prevented from having direct access to network management or customer information. SPAs 22 are  
30 service-specific, and actual provision of a service to the system 25 is done by means of a CA 20. Hence, in practice, a CA 20 provides <sup>a</sup> customer request to an SPA 22 which then decides which other CA 20 (responsible for the resource required) should be contacted in providing the resource.  
35 Thereafter, the CAs 20 involved, the one providing the customer request and the one associated with the resource,

contact the network management agents which will set up the service.

The Network Management Agents are mainly responsible  
5 for managing resources in the fixed network (FNAs) 23 and in  
the mobile network (CLAs) 24. As shown in Figure 2 the Cell  
Agents 24 can be of various types, depending on the type of  
cell they are managing: Macro Cell Agent (CLA - M), Micro  
Cell Agent (CLA - m) or Pico Cell Agent (CLA - p). The  
10 Network Management Agents work cooperatively to collate their  
available local resources (i.e. link capacities and cell  
bandwidth) in a "resource configuration" required for a  
particular service. They also continuously update that  
resource configuration to deal with changes of delivery point  
15 for the service due to customer's mobility.

Agents communicate by passing messages of fixed  
format.

Messages have the generic form: [To, From, Job\_ID,  
Content]

20 'To' identifies the agent or list of agents the  
message is sent to, 'From' identifies the originator agent  
sending the message, job id is a marker used in tracking jobs  
through the system, and 'Content' is the inter-agent message.  
When receiving a message each agent makes its own decisions  
25 triggering an internal task and/or deciding to communicate  
with other agents sending or requesting information.

The agents' internal structure and the main functions  
performed by each of them are described in the next section.

### 30 Agents

The generic types of agent presented and their  
identifiers are:

Network management agents:

Fixed Network Agent 23 (FNA)

35 Macro/micro/pico Cell Agents 24 (CLA-M, CLA-m,  
CLA-p)

Interface management agents:

Customer agents 20 (CA)  
Gateway agents 21 (GA)  
Service provision agents 22 (SPA)

5 Network Management Agents 23, 24

The role of network management agents is to manage, monitor and cost the provision of the basic network resources needed to provide a service. Each FNA 23 is responsible for managing a network node and each CLA 24 is responsible for  
10 managing a cell transmitter 2. The mapping between various types of network management agents and the physical integrated network is given in Figure 3, where the M, m, p are identifiers for the Macro, micro and pico agents respectively.

15

i) Fixed Network Agent (FNA) 23

These agents manage the flow of data through a network node and its associated links. (It should be noted that a node in this context is a switching unit, not shown, which is  
20 smaller than a DMSU 3. Multiple nodes may be connected to a single DMSU 3, and a single FNA 23 can manage more than one node).

Knowledge (stored & updated)

- local network topology (links and node(s) managed)
- 25 - neighbouring agents topology
- active services along managed links
- bandwidth usage
- price-bandwidth table

Functions Performed

- 30 - Monitor bandwidth usage along their managed physical links
- Cooperate with other FNAs using a distributed routing algorithm to find the shortest available route in the fixed network for a requested service
- 35 - Dynamic update of the route found through the fixed network on customer departure from the area managed by the

FNA (that is, when a customer leaves the cells connected to the FNA and enters the area of another FNA)

- Cooperate with the CA 20 to find not only the mobile customer location (i.e. in which cell) but also if that is the right cell in terms of bandwidth required for the service. This facility is used for intelligent downloading of data cached when the available cell bandwidth allows it.
- Set up the service end-to-end connection merging the fixed network path with the radio paths to a customer's current cell
- Control data caching at its site and then download it along the end-to-end connected path

References are made above to "data caching". This covers the storing of data which a customer requires for transmission to the customer when the customer reaches a location at which downloading is possible. For instance, a customer may request a service requiring significant bandwidth at his/her location, and subsequently move to a location in which the bandwidth is no longer available, for instance by moving from a pico cell to a macro cell of a mobile network. The relevant data must therefore be cached until such time as the customer moves once more to a location where downloading is possible.

25

ii) Cell Agent (CLA) 24

For each cell in the integrated physical network there is a Cell Agent 24 controlling it. Macro cells are arranged so that each is connected to only one FNA 23. Micros and picos are all encapsulated in macros and are connected to the macro cell in which they are embedded. Similarly, in the event that a pico is embedded geographically inside a micro it is connected to that micro cell. As shown in Figure 3, the cell agents 24 follow the same connectivity pattern as the cell transmitters 3.

Knowledge (stored & updated)

- parent cell agent connected to
- active services using that cell's bandwidth resources

5        Functions Performed

- Monitor bandwidth usage inside the cell they manage
- Dynamic price allocation based on current bandwidth usage level
- Monitor customer entering/leaving the cell and signal their presence to his Customer Agent 20 via the parent cell agent, if any, or via a FNA 23 if connected straight to an FNA agent
- Continuously offer resources to the Customer Agent 20. The message sent includes the following tuple:  
15        [Customer\_Agent, Path, Bits, Price]

where:

Path is the paths from the FNA 23, down to that cell agent.

Bits represents the available bandwidth on offer

- 20        Price is the desired selling price worked out by the cell agent

The last function presented above is central to the system, creating the possibility for resource managers of the network providers to offer continuously available resources at variable price (depending on the current bandwidth usage) to potential customers and not only when those resources are required by a requested service. This increases the potential usage of network resources and implicitly creates new and flexible opportunities for the customer wanting to use those resources.

When a service is established (by negotiation with the resource managers) the service is implemented by the resource managers, on behalf of the network providers rather than the service providers. At this point, a data download makes use of caching facilities provided by the fixed network.

Thus, network management agents' job is to sell resource at a price that they dynamically allocate based on current bandwidth usage.

## 5 Interface Agents

### i) Customer Agent (CA) 20

The role of the Customer Agent 20 is also very important in the system. It provides a 'one interface per customer' facility for various types of customers.

10 A main role is to present and negotiate customer requests for services with the system. Another major role however, is to offer proactively various services to the customer when and where they become available to him/her.

15 Additionally, a customer may not only request a service but may also offer resources that other customers want to use (i.e. databases of information, people resources). The functions of the Customer Agent can be expanded to take this into account. The following provide examples of relevant customer agent types:

- 20 - Personal Customer Agent (deals with a person offering services or capturing services requirements)
- Database Customer Agent (manage data resources, sell data to other agents/customers)
- Computer Customer Agents (manage processor resources, provision of on/off line computation power)

25 For the purposes of the present description, further details of the design/function requirements of the first two types of Customer Agent 20 are given below. (These are relevant to the descriptions of the system in use given under  
30 "Scenarios and Services" below.)

### Personal Customer Agent

#### Knowledge (stored & updated)

- customer's current location
- 35 - customer's business profile (history of services requested by the customer, although this may be a facility of

a future business agent which may be added to the current system)

- generic range of services offered by the relevant operator
- 5 - payment requirements pre-input by the customer (optional)
- billing and pricing information

#### Functions Performed

- 10 - customisable interface (one customer agent is created for each customer)
  - takes customer's request for service information and mediates the dialogue with the service provider agents (SPA) 22 sending information back to the customer
- 15 - receives resource offers at a certain price from the network management agents 23, 24 and matches them against the range of services deciding which services can be provided to the customer
  - allocates prices to services based on the price of network resources on offer and weights them in accordance to customer's business profile
- 20 - offers those services to the customer (i.e. sends available service information (Service\_Type, Price) to appear as distinctive icons on the customer's mobile handset display: the customer deciding to take advantage of the service offer then has only to select the relevant icon)
  - after taking in the customer request for a service, puts it forward to the service provider agent 22 (eg Road Map Provision agent) and then sends a request to the relevant network management agents 23, 24 for service set-up)
- 30 - all incoming services are checked by a CA 20 before contacting the customer (to take account of call blocking, priority interruptions)
  - while a service is active and the customer is moving
- 35 the Customer Agent continuously sends messages updating customer's current location to the network management<sup>agents</sup> 23, 24 for route (of the service) update

- Monitor service quality (if there is not enough bandwidth for that service in the current customer's cell, the CA 20 receiving the resource offer from the cell may decide to downgrade the service - eg video link to audio -  
5 if this is agreed by the customer, or use the caching facility, in the case of data transfer to the customer, to put the service on hold till a new 'valid' bandwidth offer arrives from another cell the customer moves into)

- take customer request to cancel the service and inform  
10 the other agents responsible for the service (i.e. the network management agents 23, 24 to release the bandwidth previously used in the service) .

In the early stages these agents will check a request against internal criteria, price it by business directed  
15 pricing and establish contacts with the resource management agents to build the service. Later generations will learn patterns of customer behaviour, price services to stimulate revenue inside the constraints set by business agents and negotiate the best rate for the necessary resources.

20

#### Database Customer Agent

The Database Customer Agent is the interface attached to any bank of data that the system may facilitate access to, for various other personal customers.

25

#### Knowledge (stored & updated)

- Database location and its connectivity to the physical network
- generic range of items offered by the database
- 30 - generic payment information
- current utilisation of database resources

#### Functions Performed

- allocate prices to database services based on the  
35 current utilisation of data resources
- offer those priced services in response to the service provider agent's request

- after being chosen by the service provider agent 22 as a source of data, the Customer agent 20 sends a request to the relevant network management agent 23, 24 (closest FNA 23) for data caching.

- 5 - when it receives the network management agent (closest FNA 23) acknowledgement the Database Customer Agent validates the transfer of data to be cached at FNA 23 site.

ii) Gateway Agent (GA)

10 Gateway agents <sup>translate</sup> between systems, effectively providing a language translator enabling different systems to negotiate. If the other system is not intelligent and does not negotiate, the gateway agent can act as a shell providing an intelligent interface. Note this suggests one gateway  
15 agent per network interface.

Service Provision Agents 22

Service provision agents 22 are not a generic family. Each type of service that can be offered is operated by a  
20 service provision agent. Their job is to provide the link between *services* and network. For simple point-to-point services such an agent is relatively simple. However by breaking service provision down in this way we can provide intelligence where it is needed. A service provision agent  
25 22 can buy and sell (negotiate for) data, computing resources, people or network bandwidth from the customer agents interfacing with such resources or from network management agents.

This enables the provision in a simple fashion of new  
30 intelligent services. Rather than describe all the possible details of such agents, a typical example is given below as the SPA agent used below in the "Intelligent Services" scenario.

35 Knowledge (stored & updated)

- Engineers it is managing
- Customers registered with the service

- Generic employment information
- List of customers in need of service
- Know where data on cars is located

#### 5 Functions Performed

- request time-distance to customer from engineers
- match engineers to customers
- inform engineers of next job
- buy car repair data to pass to engineers in need

10

This service provision agent provides the network operator effectively with two customers - the person who is requesting the service and the company (service provider) who runs the breakdown service. Service provision agents 22 can  
15 act on behalf of more than one network customer.

#### Scenarios and Services

The following three scenarios have been chosen to demonstrate use of the service provision system described  
20 above.

#### Interactive Service Provision

In this scenario a customer moves between different types of radio cell. The system will detect such cell  
25 changes and uses the cell change to inform the customer's home register of his location. In this scenario a "hardware" signal is directed to the cell agent 24 and the phone effectively represents the customer. This cell agent 24 examines the current traffic load in the cell and uses an  
30 algorithm to select a capacity and price for use of the cell's facilities. It then offers this capacity-price tuple to the customer agent 20 of that customer. The customer agent 20 then checks the range of services that the customer has subscribed to, including any price limits the customer has  
35 requested, checks the price offered by the cell against any current business strategies for pricing calls and offers a list of service-price tuples to the customer's phone unit.

These are displayed as icons on a display of the phone unit, with appropriate pricing included.

The services offered will vary from cell to cell, with available capacity. A point-to-point continuous service that is extant on crossing a cell boundary but which requires more capacity than is then available, in the new cell, or which would require a significant increase in cost (say a video call on moving into a macro cell from a micro), will be either downgraded by the customer agent to a lower call type, or will show an increased cost. Data services which do not require a continuous link are managed differently (see "Intelligent Data Services" below). The services displayed can include normal telephony, compressed video, full video, one-touch emergency services and two data download services, for instance.

It is envisaged that this iconic interface gives rise to the following significant advantages:

- \* The customer can see all the services available in a given cell at a single glance
- \* Price information is available at the point of sale
- \* Marketing can be done at the point of sale

This scenario shows the interworking of network and customer agents.

#### Intelligent Data Services

In this scenario the customer and network agents 20, 23, 24 combine to download data intelligently. A customer requests a data download to his computer, or road maps to his video phone etc. It is assumed that his machine wants the data quickly and cost effectively. The parameters on either could be set by the customer. For instance, the customer might specify that he wants data to be downloaded at 64 Kbit/s. He may however be in a typical macro cell, offering only a voice channel (8 Kbit/s). The data is then retrieved, and cached by a fixed network agent (FNA) 23, but not sent yet to the customer.

The network agent 24 requests that the customer agent 20 informs it as soon as the customer is in a cell with the right price-capacity values. Once informed the network agent 23 downloads as much data as possible until the customer agent 20 informs it that the customer is again changing cells. The data connection thus tracks the user round the system, exploiting the available capacity (or price) as available.

#### 10 Intelligent Services

A third scenario demonstrates intelligent service agents. Their job is to coordinate customer agents 20 and network resources as appeared in the previous scenario. In this scenario they demonstrate value-added intelligence of their own.

A customer is in a car which breaks down. He touches the "emergency breakdown" icon on his screen. The call is connected to a service provider agent (SPA) 22 which requests location and fault description. The service provider agent 22 manages a group of engineers in the field. It interrogates their customer agent 20 with whom each engineer logs his current job status. The service provider agent 22 negotiates with the customer agent to find an engineer who can most quickly be directed to the job then downloads the information required to the engineer. The service provider agent 22 thus acts on behalf of two customers - the broken down customer and the engineer agency. Such network intelligence could be used for<sup>any</sup> dispatch service which involves scheduling. Currently it is implemented as a reactive, negotiation based service but alternative algorithms could be implemented.

The main features of this service are:

- \* Provides a complete application for scheduling engineers
- 35 \* One touch service to customer - no numbers to remember
- \* Can be expanded to range of services with the intelligence in the network

\* Each service has a dedicated service agent - easy to produce new services.

CLAIMS

1. A service provision system for use with a communications network to provide a plurality of services to a network user, wherein data relevant to the plurality of services can be made available to the user, and the user can select one or more services to be provided, said system including control means comprising a plurality of software agents, individual agents of said plurality comprising data in respect of respective entities relevant to service provision by means of the network, said system further comprising updating means for updating data held by at least some of said software agents, the control means controlling the data made available to the user and responsive to selection of a service by the user to trigger a process for providing the selected service to the user.

2. A system according to Claim 1 wherein said communications network comprises at least in part a mobile communications network and the user has access to said mobile network.

3. A system according to Claim 2 wherein the control means is responsive to transfer of the user between cells of the mobile network, said cells having different resources to offer in respect of services to the user, to update data made available to the user which is affected by said transfer.

4. A system according to Claim 3 wherein at least one of the services potentially available to the user is affected by bandwidth availability in the cell in which the user has access to the mobile network, and the control means may update the data available to the user in terms of either availability of such service or the price at which it would be available.

5. A system according to either of Claims 3 or 4 wherein at least one of the services potentially available to the user involves the downloading of data to the user, which downloading is affected by bandwidth availability in cells of the mobile network, said system further comprising means to store data requested by the user as a consequence of selecting a service, the control means controlling downloading of said data to the user such that it is stored at times that bandwidth is not available for said downloading, and downloaded subsequently when bandwidth becomes available.

6. A system according to Claim 5 wherein the control means includes means for tracking the location of the user with respect to the mobile network for the purpose of downloading the data to the user by means of appropriate routing through the communications network or networks.

Fig.1 Integrated Fixed & Mobile Network - Physical Topology

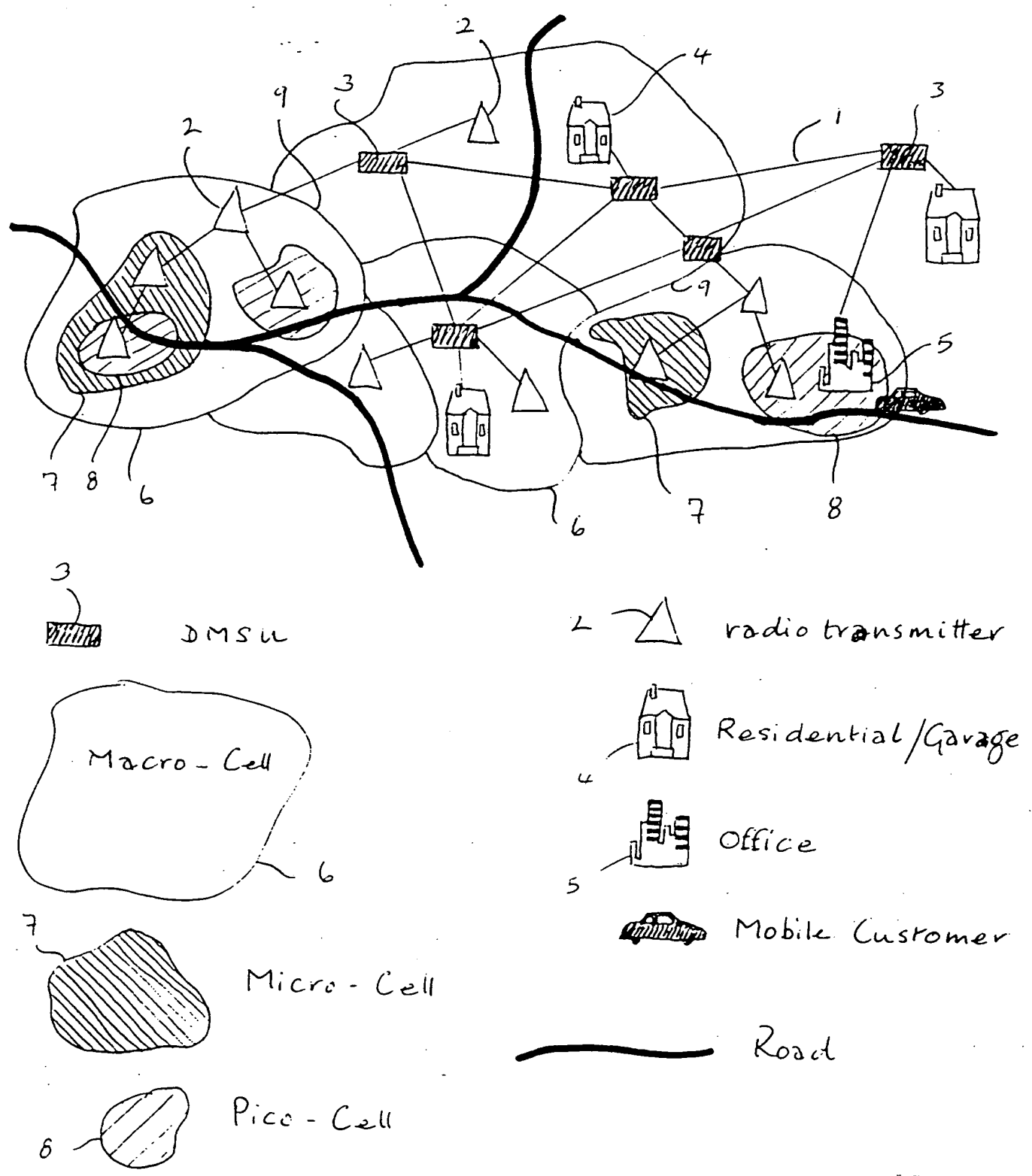


Fig. 2 Heterogeneous Agent Architecture

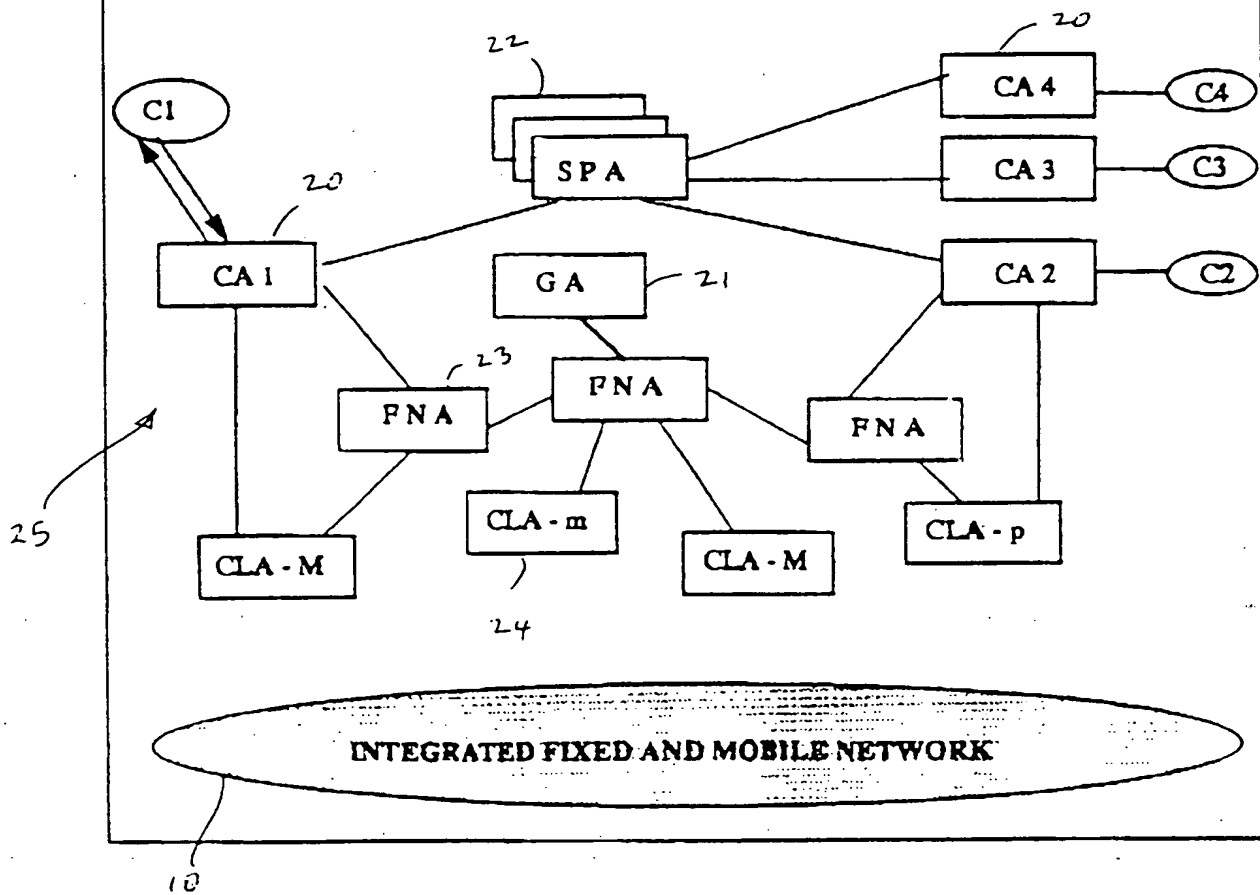


Fig.3 Network Management Agents Control over the Network

